Cooperative Communication In Near Field Magnetic Induction Communication Systems

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Abstract

Near-Field Magnetic Induction Communication (NFMIC) is a relatively new technology which has been proposed for short-range applications such as body-area networks. Since it uses a rapidly-decaying magnetic near-field instead of an electromagnetic wave as the signal transmission mechanism, it is ideal for situations in which limited transmission range is actually an advantage, such as where minimising inter-network interference or avoiding location disclosure are considered important.

To date, little work has been done on multihop techniques specifically designed for NFMIC systems. Most existing applications, such as Radio Frequency Identification (RFID) and Near Field Communication (NFC) are strictly point-to-point. However, when each network node only needs to transmit occasionally, multihop relaying techniques have the potential to significantly reduce power consumption and overall levels of magnetic field egress. Cooperative retransmission strategies, where network nodes that are neither a transmission source nor sink can participate in relaying of frames at the physical layer, have been proposed as a solution for range-extension of conventional electromagnetic/radiofrequency networks. This thesis aims to propose, analyse and simulate a variety of strategies for cooperative relaying which are appropriate for the specific needs of multihop NFMIC networks.

A link budget model for NFMIC is firstly developed and thoroughly analysed, for a variety of non-ideal channel conditions. Three relaying strategies are then proposed and evaluated using the link-budget model under a variety of channel conditions, varying from near-ideal to the pathological case, and a wide variety of source, des-

tination and relay node placement configurations. Simulation results are used to identify the key factors which govern the performance of each technique and the conditions under which throughput can be maximised. A new link metric, which accurately captures these factors, is proposed and its benefits demonstrated through simulation. Finally, a number of opportunities for future study are identified.

Statement of Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signed

Mehrnoush Masihpour
January, 2012

Dedication and Acknowledgments

To my beloved husband and my special parents:

Walking with you, through the journey of life has given me strength. Without you, my life would fall apart.

Mehdi, you are everything for me, without your love and understanding I would not be able to make it.

Mom, you have given me so much, you taught me to be strong and to pursue my dreams and never give up.

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List of Abbreviations

3D	3 Dimensional
ACE	Array Centre Excitation
AEE	Array Edge Excitation
AF	Amplify and Forward
AM	Agbinya-Masihpour
AoA	Angle of Arrival
BAN	Body Area Network
BS	Base Station
CAE	Collinear Array Excitation
DF	Decode and Forward
DL	Downlink
DSSS	Direct-Sequence Spread Spectrum
EF	Estimation and Forward
EM	Electromagnetic
FFD	Full Function Device
HF	High Frequency
IrDa	Infrared Data Association
ISM	Industrial, Scientific and Medical
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IG-BAN	Interest Group-Body Area Network
ISO	International Organization for Standardization
LF	Low Frequency

LoS	Line of Sight
LT	Location Tracking
M/A	Master/Assistant
MAC	Medium Access Control
MAMI	Master/Assistant Magnetic Induction
MI	Magnetic Induction
MIC	Medical Information and Communication
MICT	Medical Information and Communication Technology
MMAC	Mobility adoptive collision free MAC
MR-BS	Multihop Relay-Base Station
MR-Cell	Multihop Relay-cell
MS-MAC	Mobility aware MAC for Sensor Networks
MST	Minimum Spanning Tree
NFMI	Near Field Magnetic Induction
NFMIC	Near Field Magnetic Induction Communications
NLoS	Non Line of Sight
NTP	Network Time Protocol
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
PBS	Pairwise Broadcast Synchronization
PC	Personal Computer
PHY	Physical Layer
Q-Factor	Quality Factor
Ra	Relay Assistant
RBS	Reference Broadcast Synchronization
RF	Radio Frequency
RFID	Radio Frequency Identification
RFD	Reduced Function Device
Rm	Relay Master
RS	Relay Station

RSS	Received signal Strength
Rx	Receiver
SAR	Specific Absorption Rate
SINR	Signal to Interference Noise Ratio
SNR	Signal to Noise Ratio
SS	Subscriber's Station
S-TDMA	Self-Organized Time Division Multiple Access
SUI	Stanford University Interim
TC	Triangle Centroid
TDMA	Time Division Multiple Access
TDoA	Time Difference of Arrival
Tx	Transmitter
UHF	Ultra High Frequency
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UWB	Ultra Wide Band
WLAN	Wireless Local Area Network
WPSM	Warfighter Physiologic Status Monitoring
WiMAX	Worldwide Interoperability for Microwave Access